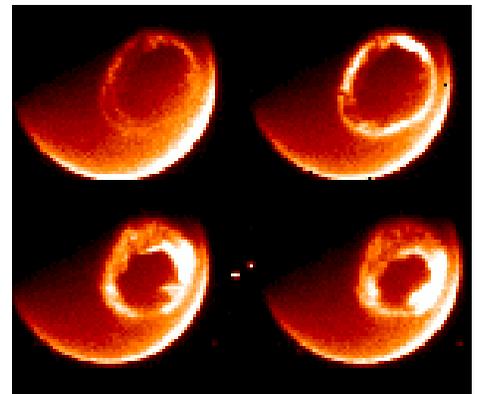
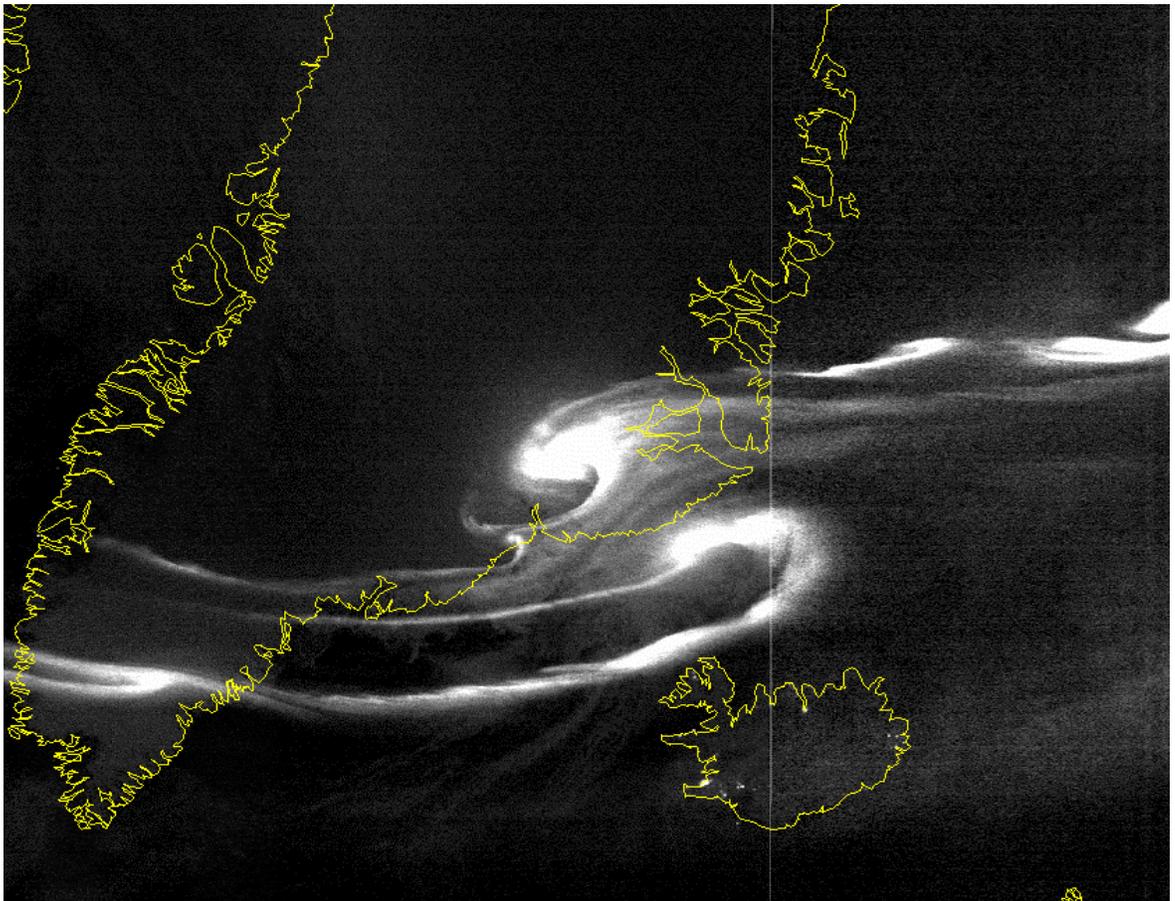


THE NORTHERN LIGHTS



A Grade 7-8 guide to understanding the Aurora Borealis through math, geometry and reading activities.

This series of activities will help students understand how the Northern Lights work, what causes them, and how to observe them.

Through a series of math and reading activities, students will learn:

How aurora are described by scientists and by other students
(Reading)

The geographic locations of aurora based on satellite data
(Geography)

How aurora appear in the sky at different geographic latitudes (Geometry)

The height of aurora above the ground (Geometry - parallax)

How to predict when they will appear (Mathematics)

What Norse Mythology had to say about aurora (symbolic code translation)

This booklet was created by the NASA, IMAGE satellite program's Education and Public Outreach Project.

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For more classroom activities about aurora and space weather, visit the IMAGE website at:

<http://image.gsfc.nasa.gov/poetry>

The cover shows a view from the NPOESS satellite looking down at an aurora over Greenland. (http://npoesslib.ipc.noaa.gov/S_sess.htm). Viking rune inscription (<http://www.commersen.se/vikingar/vardag/runor.html>). The three smaller images at the bottom of the page are: (Left) an aurora borealis viewed from the Space Shuttle; (middle) portion of the auroral oval over North America viewed by the DMSP satellite showing city lights; (right) the auroral oval viewed over the Arctic region on July 15, 2000 by the IMAGE satellite.



Activity 5

How High Up are Aurora?

For thousands of years, people living at northern latitudes had no idea how high up the Aurora Borealis was located. All you could see from any particular vantage point was a curtain of light. There wasn't much about its shape that gave you any clue to how high up it actually was. The aurora could be 1 kilometer or 10,000 kilometers above the ground and there was no real way to tell. Before the advent of photography in the 1880's, auroral observers tried to determine the height of aurora by the method of triangulation. One of the earliest of these measurements was made by the French scientist Jean-Jacques d'Ortous de Mairan between 1731 and 1751. From two stations 10-20 km apart, observers measured the angle between the ground and a specific spot on an aurora. From the geometry of the triangle, they estimated that aurora occurred between 650 - 1,000 km above the ground.

Benchmarks:

Find answers to problems by substituting numerical values in simple algebraic formulas.

Understand that writing incorporates circle charts, bar charts, line graphs, tables, diagrams, and symbols.

Technology is essential to science for such purposes as access to outer space, sample collection, measurement, storage, and computation.

Objectives:

Students will apply the concept of triangulation in a variety of problem solving situations.

Teacher Answer Key:

1. $\tan(60) = (X \text{ divided by } 57.75)$
 $\tan(60) * 57.75 = X$
 $100.0259 = X$

2. Part 1
 $\tan(87.15) = (X \text{ divided by } 5)$
 $\tan(87.15) * 5 = X$
 $100.435 = X$

Part 2
 $\tan(84.3) = (X \text{ divided by } 10)$
 $\tan(84.3) * 10 = X$
 $100.187 = X$

Part 3
 $\tan(80.1) = (X \text{ divided by } 17.5)$
 $\tan(80.1) * 17.5 = X$
 $100.270 = X$

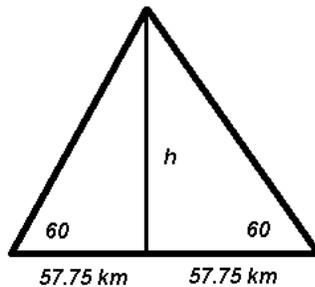
A good conjecture is that the height of all of the triangles is approximately 100 km.



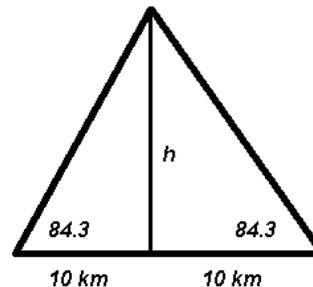
Teacher Answer Key (cont'd):

3. $100.0259 + 100.435 + 100.187 + 100.270 = 400.9179$
 400.9179 divided by $4 = 100.229475$
 Rounded to the nearest unit = 100 km.
4. Dr. Made A. Mistake missed a digit in using the angle measurement.
 These are his calculations:
 $\text{Tan}(5) = (X \text{ divided by } 8.75)$
 $\text{Tan}(5) * 8.75 = X$
 $.765 = X$
 What he should have done was the following:
 $\text{Tan}(85) = (X \text{ divided by } 8.75)$
 $\text{Tan}(85) * 8.75 = X$
 $100.013 = X$
5. Dr. Nada Written Down can use the inverse tangent to find the missing angle measure. Inverse tangent of $(100 \text{ divided by } 7.5) = 85.7$ degrees.
6. Dr. Flipped D. Numbers transposed the angle measure. He used 85.0 instead of 80.5 degrees.
 $\text{Tan}(85.0) = (X \text{ divided by } 16.75)$
 $\text{Tan}(85.0) * 16.75 = X$
 $191.453 = X$
 Corrections:
 $\text{Tan}(80.5) = (X \text{ divided by } 16.75)$
 $\text{Tan}(80.5) * 16.75 = X$
 $100.094 = X$

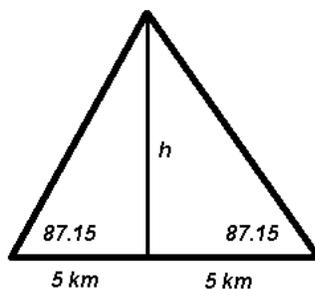
Problem 1 :



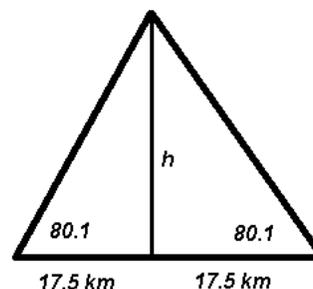
Problem 2a :



Problem 2b :



Problem 2c :



7. The missing angle measure is **30 degrees**. The two angles sum is **$30 + 30 = 60$ degrees**. The measure of angle P is **60 degrees**.

8. The missing angle measure is **$180 - 84.3 - 90 = 5.7$ degrees**. The two angles sum is **$5.7 + 5.7 = 11.4$ degrees**. The measure of angle P is **11.4 degrees**.

9. The measure of the Parallax angle is calculated as follows (see figure below):

$$180 - 87.15 - 90 = 2.85$$

$$2.85 * 2 = 5.7$$

Therefore the measure of the Parallax angle is 5.7 degrees.

10. The measure of the Parallax angle is calculated as follows (see figure below):

$$180 - 80.1 - 90 = 9.9$$

$$9.9 * 2 = 19.8$$

Therefore the measure of the Parallax angle is 19.8 degrees.

11. The measure of the Parallax angle is as follows (see figure below):

$$180 - 85 - 90 = 5$$

$$5 * 2 = 10$$

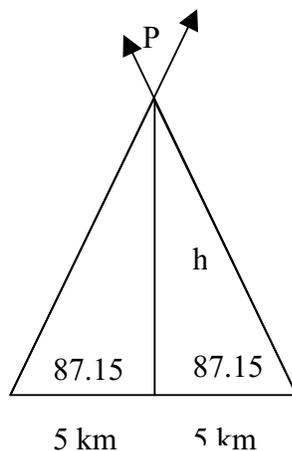
Therefore the measure of the Parallax angle is 10 degrees.

12. The parallax angle is calculated as follows:

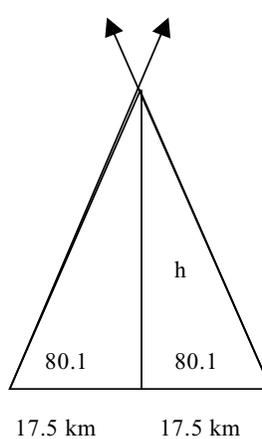
$$180 - 85.7 - 90 = 4.3$$

$$4.3 * 2 = 8.6 \text{ degrees.}$$

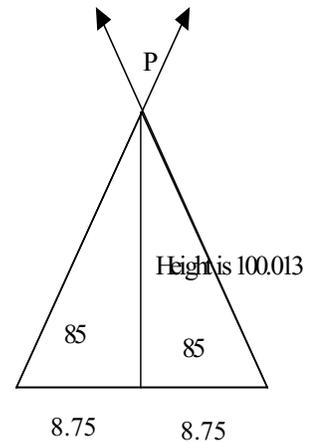
Therefore the measure of the Parallax angle is 8.6 degrees.



Problem 9



Problem 10



Problem 11



Direction: Construct or draw the figure and solve for the given unknown.

1. Draw an isosceles triangle with base angles of 60 degrees and a base length of 115.5 km. Let 21 km = 1 cm. Locate the midpoint and bisect the base. What is the approximate height of the triangle? Explain your answer using mathematics.
2. Sketch the following figures (note: not to scale).
 - A. An isosceles triangle with base angles of 87.15 degrees and the base is 10 km. Locate the midpoint of the base and draw the altitude. Calculate the height.
 - B. A triangle with base angles of 84.3 degrees and the length of the base is 20km. Calculate the height.
 - C. A triangle with base angles of 80.1 degrees and a base of length 35. Determine the height.

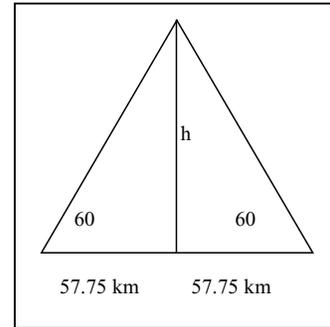
Make a conjecture (a guess) about the calculated heights.

Careful observations of the lowest limits to aurora show that they rarely are less than 90 km above the ground. Some legends insist that they can touch the ground, but this is merely an optical illusion. Their tops, however, can sometimes exceed 1,500 kilometers. Auroras require very low density air in order to produce their light. If the air is too dense, as it is below 90 kilometers, the physical process that produces the light does not work. The atoms in the denser air collide faster than the time it takes for the atom to produce the light.

3. Suppose each of the four problems above were recorded by four different scientists studying the same aurora feature. Based on your calculations, what is the average height to the nearest unit?
4. Dr. Made A. Mistake, a fifth scientist, was out of luck. He calculated the height to be 0.765 km. He measured the base angles to be 85 degrees and the length of the base was 17.5km. Show the correct calculations for the height and determine his mistake.
5. Dr. Nada Written Down, another aspiring young scientist, did not write down her calculations. She remembered that the height was 100 km and that the base length was 15 km. Can you determine the missing base angles?
6. Dr. Flipped D. Numbers is having a tough time figuring out where the mistake is in the calculations. The base length was 33.5 km and the base angles were 80.5 degrees. The height that he determined was 191.45 km. How could he have made this mistake?

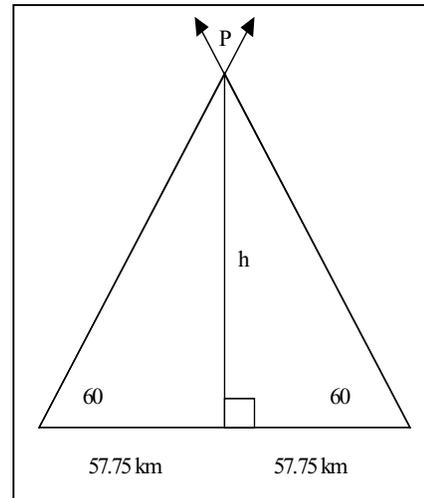


7. To the right is the completed drawing for Problem 1.

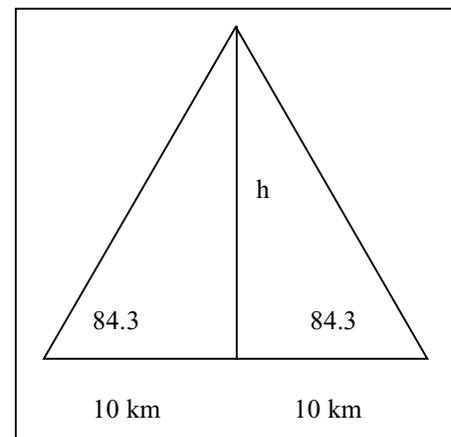


The legs have been extended to create angle P. This angle, P, is referred to as the Parallax angle. The height is perpendicular to the base. Since two angles are known for each of the two smaller triangles, and it is known that the sum of the angles of a triangle are equal to 180 degrees, the third missing angle measure for each triangle can be calculated.

The missing angle measure is _____. Since both angles at the top are congruent, then their sum is _____. These angles and angle P form vertical angles. Therefore, the measure of angle P is _____.

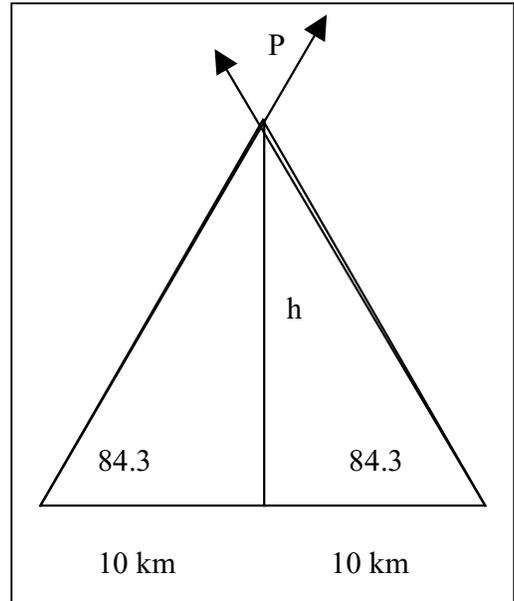


8. The completed drawing for Problem 2a is shown to the right.

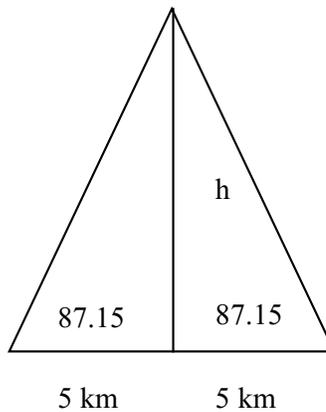


The legs have been extended to create angle P. This angle, P, is the Parallax angle. The height is perpendicular to the base. Since two angles are known for each of the two smaller triangles, and it is known that the sum of the angles of a triangle are equal to 180 degrees, the third missing angle measure for each triangle can be determined.

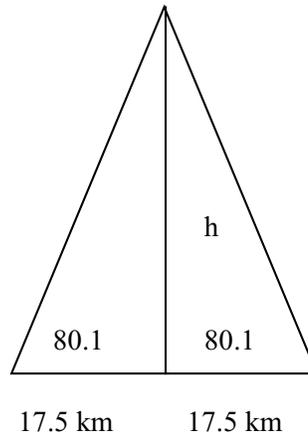
The missing angle measure is _____. Since both angles at the top are congruent, then their sum is _____. These angles and angle P form vertical angles. Therefore the measure of angle P is _____.



9. Below is the completed drawing for Problem 2b. Draw in the Parallax angle and then determine the measure of the Parallax angle.



10. Below is the completed drawing for Problem 2c. Draw the figure showing the Parallax angle and then determine the measure of the Parallax angle.



11. Draw and label a diagram for Problem 4. Extend the drawing to include the Parallax angle. Determine the Parallax angle measure based on the given information and the correct answer for problem four.

12. Using Problem 5 determine the Parallax angle using any method.



Useful Web Resources

Exploratorium "Auroras:Paintings in the Sky"

http://www.exploratorium.edu/learning_studio/auroras/

Archive of aurora photos by Jan Curtis:

<http://www.geo.mtu.edu/weather/aurora/images/aurora/jan.curtis/>

Archive of aurora photos by Dick Hutchinson:

<http://www.ptialaska.net/~hutch/aurora.html>

Space Weather Today:

<http://www.spaceweather.com/>

IMAGE real-time aurora images from space:

<http://image.gsfc.nasa.gov/poetry/today/intro.html>

<http://www.sec.noaa.gov/IMAGE/>

<http://sprg.ssl.berkeley.edu/image/>

NOAA Auroral Activity monitor:

<http://www.sec.noaa.gov/pmap/index.html>

CANOPUS real-time auroral monitor:

<http://www.dan.sp-agency.ca/www/rtoval.htm#TOPOFPAGE>

Current solar activity report:

<http://www.dxlc.com/solar/>

Alaska Science Aurora page for kids:

<http://www.alaskascience.com/aurora.htm>

Human Impacts of Space Weather:

<http://image.gsfc.nasa.gov/poetry/weather01.html>

Ask the Space Scientist:

<http://image.gsfc.nasa.gov/poetry/ask/askmag.html>

More classroom activities:

<http://image.gsfc.nasa.gov/poetry/activities.html>

The Northern Lights Essay Competition:

<http://image.gsfc.nasa.gov/poetry/alaska/alaska.html>

